The Role of Healthcare Systems During Crisis: Analyzing the Impact of Healthcare System Structure on COVID-19 Outcomes

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I. Introduction

On March 11, 2020, the World Health Organization officially declared SARS-CoV-2, commonly referred to as COVID-19, a global pandemic. The virus spread rapidly through the entire world, and over 100 countries recorded infections in a matter of weeks. The pandemic's negative effects were felt immediately and have persisted up to the writing of this paper. As of May 1, 2021, 150,989,419 confirmed cases and 3,173,576 fatalities from the virus were reported to the World Health Organization[1]. The enormous health impact has been coupled with an equally devastating economic effect globally. Health care systems have been strained and overwhelmed, as intensive care units (ICUs) and hospital bed capacities have been pushed to their limits. Responses to control the spread of the virus have varied by each country, resulting in some countries experiencing a low recorded number of COVID-19 infections and fatalities, while others having reported much higher infections and fatalities. The United States has endured the most significant impact of the pandemic, as they have the highest number of total confirmed cases and fatalities of any country in the world at the time of this writing. However, there have been many disparities in access to care during the COVID-19 pandemic between countries, leading to many populations being underserved and more exposed to the virus.

These challenges have brought framework and stability of global healthcare systems into question. Countries have utilized differing methods of care delivery resulting in each having their own form of a health care system—single-payer, out-of-pocket, etc.—and not all have responded equally to the pandemic. Efficiency, quality, and access to care have driven the conversation surrounding healthcare during the pandemic and in the decades preceding it. Healthcare systems

[1] "WHO coronavirus disease (COVID-19) dashboard". Geneva: World Health Organization, (2020). https://covid19.who.int/info/

can generally be categorized into four different models—Beveridge (BEV), Bismarck (BIS), National Health Insurance (NHI), and Out-of-Pocket (OOP) models. In the Beveridge model, the central government mandates and regulates healthcare while also acting as the primary source of delivery in the healthcare continuum. In the model, health is viewed as a human right and is guaranteed to anyone who is a citizen and has access to care. The government acts as single-payer, which eliminates competition, keeping prices low and standardizing health benefits for the full population. The Bismarck model is a more decentralized version of care, in which healthcare coverage is mandated and regulated by the central government but delivered through private payers and providers. However, despite the usage of private institutions, the population is still fully covered, while the government takes a more hands-off role. NHI is a blend of the previous two models, in which the central government acts as single-payer, mandates coverage, and regulates care, but providers are allowed to remain private. Coverage is still universal and covers most procedures, regardless of one's income level. Lastly, in the Out-of-Pocket model, the government does not ensure coverage for any group, and individuals are left to pay for healthcare on their own. This system leads to the most unequal access to care, because disparities in income result in disparities in health outcomes.

The entire spectrum of health care delivery has come under intense scrutiny in the past year. There have been examples of countries, such as New Zealand, that have shown tremendous success in mitigating the spread of the virus, allowing their society and economy to reopen. Meanwhile, the United States has one of the highest deaths rates, constraining the country's ability to escape the grip of the virus. Developing countries have seen thousands of infections and deaths go unreported and underreported, resulting in inaccurate estimates of case counts and fatalities. Attempts to slow the spread of the virus from a policy level include testing, school closures, workplace closures, cancellations and restrictions on public gatherings and public transport, stay-at-home requirements, mask mandates, border closures, and public information campaigns. These policy initiatives, in collaboration with healthcare systems, have proved effective at diminishing the spread of the virus.

Due to the fact that healthcare systems play such an integral role in individuals' outcomes, it is important to analyze the impact of each of these healthcare systems structures on COVID-19 outcomes. Various studies have attempted to look at comparisons of health system outcomes, including Woolf and Aron (2013) who state that cross-national health system comparison cannot yet provide any definitive conclusions about the effectiveness and equality of one over another, but this paper will attempt to do so. Thus, this paper will attempt to estimate the impact of healthcare systems on COVID-19 outcomes.

II. Literature Review

Health system equality and efficiency has become magnified since the beginning of the pandemic. Current literature looks at efficacy in healthcare systems responding to the challenges brought on by the pandemic, such as loss of coverage, increasing costs, and limited capacity. Vadlamannati et al. (2021) found that greater equity in access to health care and improved health system capacity are the two leading factors in dealing with the societal impact of COVID-19. Meanwhile, in the U.S., 40% of people or their spouses who lost a job or were furloughed during the pandemic also lost their insurance, which could increase the estimated uninsured population to 40 million from 31 million, according to Blumenthal et al. (2020). Policy has been required to ensure coverage for Americans during the crisis, increasing the role of government in the healthcare system of the U.S, and placing more pressure on private insurers. However, external factors exist that impact outcomes from the virus as well, including comorbidities, governmental policies, and demographic factors.

The efficacy of different types of healthcare systems has been a controversial topic, as proponents of a single-payer system suggest that their care delivery is better than that of private systems, and vice versa. Basu et al. (2012) found that private sector healthcare systems, especially in low and middle-income countries, lack published data, but overall, they resulted in greater risks of lower-quality care. The trend is not confined to lower and middle-income countries, as it continues in the United States, which relies heavily of private insurance; they spent 16.9% of the GDP on healthcare in 2019, leading all other OECD countries substantially[2]. Woolf and Aron (2013) found that Americans are more likely to find care inaccessible or unaffordable, and to report lapses in the quality and safety of care outside of hospitals. However, their findings suggest that Americans' health outcomes are not entirely attributable to their health care system as lifestyle, socioeconomic status, and public policy all play integral roles. Countries with Beveridge, Bismarck, and NHI systems also have inefficiencies and problems that plague their system. According to Brown (2003), budget constraints on health spending in the United Kingdom have constricted accessibility to care and generated long wait times for non-serious medical emergencies.

Various studies have looked at the susceptibility of certain populations to COVID-19. Chaudhry et al. (2020) found that increasing COVID-19 caseloads were associated with higher obesity, higher median population age, and longer time to border closures from the first reported case. Meanwhile, not only caseloads but also mortality was associated with low levels of national

[2] Tikkanen, Roosa. "Multinational Comparisons of Health Systems Data, 2019" Commonwealth Fund (2020). https://www.commonwealthfund.org/publications/other-publication/2020/jan/multinational-comparisons-health-systems-data-2019

preparedness, scale of testing, and population characteristics. Sorci et al. (2020) identified the role of comorbidities, such as percentage of population over 70, smoking rate, and population with chronic respiratory diseases, as well as socio-economic factors, like GDP per capita and level of democracy, as possible driver of COVID case fatality rate at the population level.

This paper will isolate the role of healthcare systems to determine their true impact on COVID-19 outcomes. Variables such as comorbidities, governmental policy, population density, GDP per capita, as well as other demographic variables will be controlled for within the model. COVID-19 infections and mortalities are caused by many different variables, but this regression will attempt to control for as many as possible. There currently exists no literature about the specific effect of health system structure on COVID-19 outcomes; this paper will attempt to provide analysis to whether a specific type of health system has succeeded or failed, what flaws have been uncovered, and the inequalities exposed by the pandemic.

III. Methods

Data for this paper was obtained from Our World in Data, a science and data publication that focuses on social and economic problems such as health, poverty, climate change, and more. They include a comprehensive set of COVID-19 statistics including case count, hospital admission, population density, comorbidities, and government policy for each country throughout the pandemic. Our World in Data extracts the data from the COVID-19 Data Repository by the Center for Systems Science and Engineering at Johns Hopkins University, and it is updated on a daily basis. The sample of data used in this study was collected between January 1, 2020 and December 8, 2020. The initial date was chosen because the data set does not include any statistics prior to January 1, 2020. The ending date was chosen because it was the first day that the COVID-19 vaccination was administered, which occurred in the United Kingdom. This study leaves out data after the vaccines became available due to the uneven distribution of vaccines throughout the world, and the reliance on drug manufacturers and distributors within each country to deliver the vaccines.

The countries chosen for the model will be divided into the four main health system types listed in the introduction of this paper—Beveridge, Bismarck, NHI, and Out-of-Pocket. The Beveridge model contains the United Kingdom, Spain, Italy, and New Zealand; Bismarck consists of Germany, France, Japan, Switzerland, and The Netherlands; NHI is Canada, South Korea, Israel, Mexico, and Brazil; and, Out-of-Pocket comprises the United States, China, Indonesia, and India. Only a limited set of countries are used in this study because of the unreliability of COVID-19 testing and reporting in various countries globally. Countries with demographic similarities are included because a comparison between two countries with completely different socioeconomic structures, such as the United States and Cambodia, would not be reasonable. Additionally, many countries lack a defined health system, which would have complicated the analysis even more, so only countries with a defined health system are included. Thus, these countries were chosen and placed into their specific health system models due to homogeneity and reliability of data reporting. The homogeneity of the countries will help eliminate some external factors that could affect COVID outcomes, utilize more trustworthy data, and provide a more accurate analysis.

The dependent variable being tested is total deaths per million. Other dependent variables of interest are ICU patients per million and hospital admissions per million, but due to a lack of data and potential admissions for non-COVID related emergencies that could complicate the data, these two variables are not tested in the analysis. The independent variable of interest is Health

System Type, so this paper is analyzing the effect of Health System Type on total deaths per million. The other independent variables in the regression will consist of demographic, comorbidity, and government policy variables, all of which will control for external factors that have an effect on COVID outcomes. Demographic variables are population density and Human Development Index, an index from 0 to 100 created by Our World in Data that measures key dimensions of human development—life expectancy, expected years of schooling, mean years of schooling, and GNI per capita. Variables that track comorbidities will also be included, and they are the percentage of population over 70 years old, obesity rate (defined as the share of adults who are obese, as of 2016), and smoking rate (defined as the share of all people older than 15 years old who smoke, as of 2016).

Lastly, this regression will include two government policy variables. The first is face coverings, which is coded from 1 to 5 based on each country's most stringent sub-national policy. This will be averaged over the time period tested, as each face covering policy has fluctuated and changed for each country since the start of the pandemic. Second is Government Stringency Index which is an index from 0 to 100 created by Our World in Data that uses nine metrics to estimate how strict the governmental approach has been to COVID—school closures, workplace closures, cancellation of public events, restrictions on public gatherings, closures on public transport, stay-at-home requirements, public information campaigns, restrictions on internal movements, and international travel controls. There are many other explanatory variables that effect COVID-19 outcomes that were not included in this paper, such as hospital beds per thousand and tests per thousand, because of unreliability of data reporting or a lack of data presented for these variables.

A regression on the averages of data collected from January 1, 2020 to December 8, 2020 will be used in this model to track healthcare system efficacy during the COVID-19 pandemic. This model will incorporate all of the healthcare systems and the control variables to isolate the effect of the health system on outcomes of the virus.

Thus, the following regression was constructed:

$$\begin{aligned} &Total\ Deaths\ Per\ Million \\ &= \beta_0 + \beta_0 BEV + \beta_0 BIS + \beta_0 NHI + \beta_0 GSI + \beta_0 HDI \\ &+ \beta_0 Pop. Density + \beta_0 Age\ 70\ and\ Older + \beta_0 Obesity\ Rate \\ &+ \beta_0 Smoking\ Rate + \beta_0 Face\ Covering + \varepsilon \end{aligned}$$

The variables BEV, BIS, and NHI are all dummy variables that equal 1 if the country is Beveridge, Bismarck, and NHI, respectively, and 0 otherwise. Out-of-pocket was left out of the equation to avoid collinearity, so the regression will test the expected total deaths per million relative to the out-of-pocket countries. The other explanatory variables are tested as defined previously. Although these are not the independent variables of interest, their inclusion is still necessary as they are all factors that impact COVID-19 related deaths.

IV. Data

Summary statistics on the explanatory variables can explain how each health system is impacted from COVID, demographics, comorbidities, and governmental policy. *Tables 1 and 2* includes all of the summary statistics broken down by each category. For COVID-specific variables, Out-of-Pocket had the lowest total deaths per million, which is impacted principally from very low COVID-related deaths in China and Indonesia. Meanwhile, NHI countries experience the highest total cases per million and Beveridge countries have the highest total deaths per million from COVID-19 from January 1, 2020 to December 8, 2020.

Further analysis of the summary statistics shows that out-of-pocket countries have the third lowest population density of the healthcare systems, the lowest population aged 70 or older, and the lowest obesity rate. Meanwhile, these countries also have the highest government stringency index and face covering policies. Beveridge countries, on the other hand, have the highest deaths per million which could be attributed to a high number of deaths in the U.K., Spain, and Italy, even though New Zealand has the lowest deaths per million of any country analyzed. These countries have a lower number of hospital beds per thousand, government stringency index, and face covering policies and a higher human development index compared to the other healthcare systems. They have above average comorbidities and significantly more tests per thousand compared to the other healthcare systems as well. NHI countries have the highest number of cases per million in the set, but they have below average deaths per million. They have relatively average marks in demographic and comorbidity variables, while also having about average governmental policy variables. Lastly, Bismarck countries are slightly below the mean for total deaths per million and cases per million. Bismarck countries have below average governmental policies, but higher comorbidity variables, aside from obesity rate. They also have the highest population density of the group, and the highest number of hospital beds per thousand of the group as well. These variables taken in conjunction with the results of the regression can help explain COVID-19 outcomes by health system.

The regression ran on total deaths per million did not result in statistical significance for any of the healthcare systems analyzed at the 95% confidence level. Results of the regression on total deaths per million can be seen in *Table 3*. Out-of-Pocket countries had the lowest total deaths per million in comparison with the other countries. Beveridge countries had a coefficient of 331.12, which means that expected total deaths per million were approximately 331 higher in Beveridge countries relative to out-of-pocket countries. Bismarck countries had a coefficient of 249.98; in other words, expected total deaths per million were roughly 250 higher in Bismarck countries than in out-of-pocket countries. Lastly, NHI countries achieved a coefficient of 71.42, which is an expected total deaths per million 71 higher relative to out-of-pocket countries.

To eliminate bias within this regression, explanatory variables on demographics, comorbidities, and governmental response were included. These results also proved to be statistically insignificant at the 95% confidence level, but their interpretations within this regression still provide useful insights. For the demographic variables, population density showed a small but positive effect on total deaths with a coefficient of .035, but human development index had a positive coefficient. This suggests that countries with more advanced human development had higher deaths per million. This result can be supported by looking at individual country outcomes from the COVID-19 pandemic, as countries with a higher HDI, such as the U.S. or U.K., experienced some of the worst impacts. In regard to comorbidity variables, population aged over 70 and obesity rate both have a positive impact, suggesting that these two comorbidities cause higher total deaths per million, supporting prior research.[3] However, smoking rate had a negative coefficient, which may show flaws within the data, as this contradicts the previously cited research, albeit with statistical insignificance. Lastly, for governmental factors, both face coverings and government stringency index had positive coefficients. This result also proves that there may exist inaccuracies within the dataset and would require further research.

[3] Elezkurtaj, S., Greuel, S., Ihlow, J. *et al.* “Causes of death and comorbidities in hospitalized patients with COVID-19”. *Sci Rep* 11**,** 4263 (2021). https://doi.org/10.1038/s41598-021-82862-5

Due to the statistical insignificance of the results, it can be reasonably be concluded that far too many factors exist that can influence the total deaths per million from COVID-19. This regression included many explanatory variables within it, but the dataset would need to be more comprehensive and include more explanatory variables and countries to accurately describe the effect of healthcare systems on COVID-19 outcomes. Additionally, these results show data that goes against conventional wisdom. It could be reasonably expected that a face covering policy should lower total deaths per million, or that smoking rate would raise case fatality rate, but the results of this analysis show otherwise, albeit without statistically significant results. Thus, more research needs to be conducted on this topic in order to reach a conclusion.

V. Conclusion

This paper cannot conclusively state whether or not healthcare systems had a marginal effect on COVID-19 outcomes due to the statistical insignificance of the results. However, it brings about some useful insights about health system performance, equality, and efficiency, nonetheless. Despite the fact that Beveridge, Bismarck, and NHI countries provide health care coverage for all of their citizens, this analysis shows that they in fact performed worse in preventing COVID-related deaths relative to Out-of-Pocket countries. This is surprising given the disparities in access to healthcare providers for Out-of-Pocket countries, as their populations may face constraints to access care due to cost. One possible explanation of this result is the ability to circumvent government regulations that could have potentially slowed down testing and contact tracing. The Out-of-Pocket countries results go against prior research that suggests that lower-income countries have greater risks of low-quality care. This analysis also shows which type of universal coverage system has responded most effectively to the pandemic.

Bismarck and NHI countries, which both incorporate and utilize private providers, had low total deaths per million. Beveridge countries, who provide and mandate coverage entirely through the central government, had the largest marginal effect on COVID-related deaths. Therefore, this study raises the question of whether or not utilizing private payers and providers in the health system can result in a more efficient and equitable response during times of health crises.

It is also useful to look at comorbidities from each health system analyzed in order to better interpret the results of this study. Previous research suggests that comorbidities such as age, obesity, and smoking all place individuals at a higher risk of dying from COVID-19[4]. The results of the regression do not entirely support this research. For instance, smoking rate had a negative impact on total deaths per million. Meanwhile, from governmental policies aimed at limiting the spread of COVID, both the government stringency index and face coverings had positive coefficients, which imply that these policies had a positive effect on deaths from COVID. Given previous research and the surprising results of this regression, it becomes clear that there are limitations in this data and that the dataset itself is flawed.

This analysis had constraints, and it primarily stemmed from uneven and unreliable COVID data. The limitations resulted in only a limited set of countries that could be included into the regression, as many countries have inaccuracies in reporting COVID cases and deaths. This, in turn, further limited the dataset used as all countries included needed to have homogeneity and similarities. For example, countries in sub-Saharan Africa could not be included into this analysis as their COVID reporting is unreliable and because they are socioeconomically very

[4] Chaudhry Rabail et al. "A country level analysis measuring the impact of government actions, country preparedness and socioeconomic factors on COVID-19 mortality and related health outcomes." EClinicalMedicine, Volume 25 (2020): 1-8.

different than the developed countries in this study, such as the U.S. and Western European countries.

Overall, this study found that Out-of-Pocket countries had the lowest marginal effect on number of deaths per million associated with COVID-19 compared with countries of the single-payer Beveridge model. Additionally, Bismarck and NHI countries also had a smaller effect on deaths per million compared with Beveridge countries. This finding challenges the idea that a single-payer system provides its citizens with the highest quality of care. It suggests that utilizing private providers and payers may play a role in responding to COVID-19 outcomes quicker due to its ability to more efficiently and effectively respond to the challenges brought up by the health crisis. Because of this finding, it is apparent that another study that includes a larger set of countries and explanatory variables needs to be conducted in order to accurately state whether or not health system type has an effect on COVID-19 outcomes. Once the pandemic ends, equality and efficacy of healthcare systems will become essential needs that will have to be addressed in order to provide better care and coverage in the immediate and long-term future.

Results of the paper suggest that there may exist a relationship between a countries' health system and their health outcomes from COVID-19. However, since there is no statistical significance, no definitive conclusion can be reached. The statistical insignificance does suggest, though, that other factors exist outside the scope of this paper that have an influence on COVID-19 outcomes. For example, ethnicity is one potential variable, as Williamson et al. (2020) found that compared with White people, Black and South Asian people were at higher risk of death after contracting COVID-19. In order to provide a statistically significant conclusion to answering if health system type had an impact on COVID-19 outcomes, an analysis that includes a greater number of countries and explanatory variables is necessary.

VI. Tables

Table 1: Summary Statistics – Mean and Standard Deviation

	Total Cases per Million	Total Deaths per Million	Total Tests per Thousand	Hospital Beds per Thousand	Population Density	HDI
BEV	5449.48 (3949.99)	404.42 (268.26)	151.72 (46.85)	2.82 (0.30)	147.51 (113.73)	0.90 (0.02)
BIS	5148.55 (3287.14)	214.67 (162.66)	80.46 (51.71)	6.97 (3.82)	286.03 (147.98)	0.92 (0.02)
NHI	6285.15 (5741.03	215.96 (165.38)	80.78 (97.68)	4.26 (4.51	205.21 (242.55)	0.85 (0.08
OOP	3739.33 (5973.26)	120.49 (200.06)	82.68 (90.62)	2.16 (1.74)	194.85 (78.24)	0.75 (0.12)
Total	5217.99 (4453.88)	236.27 (206.13)	97.84 (76.08	4.23 (3.53)	212.54 (171.92)	0.86 (0.09)

	Population Aged 70 or Older	Obesity Rate	Smoking Rate	GSI	Face Coverings
BEV	13.07% (271.40%)	25.57% (4.75%)	22.82% (5.46%)	56.38 (9.90)	1.63 (1.06)
BIS	14.41% (275.46%)	18.86% (8.37%)	26.14% (5.56%	49.32 (9.95)	1.42 (0.56)
NHI	7.23% (263.86%)	22.24% (10.22%)	18.14% (5.62%)	59.25 (7.41)	2.23 (0.68)
OOP	5.53% (307.84)	13.05% (15.53%)	24.57% (11.54%)	65.16 (6.12)	2.71 (0.23)
Total	10.15% (461.15%)	20.00% (10.40%)	22.83% (7.24%)	57.16 (9.73)	1.98 (0.81)

** Standard Deviations are listed in parenthesis*

Table 2: Summary Statistics – Maximum and Minimum

	Total Cases per Million	Total Deaths per Million	Total Tests per Thousand	Hospital Beds per Thousand	Population Density	HDI
BEV	9933.65 (307.52)	577.89 (4.40)	216.63 (111.84)	3.18 (2.54)	272.90 (18.21)	0.92 (0.88)
BIS	7867.32 (340.54)	405.45 (7.76)	129.44 (7.60)	13.05 (3.32)	508.54 (122.58)	0.94 (0.90)
NHI	12975.13 (293.81)	401.34 (5.88)	234.95 (6.44)	12.27 (1.38)	527.97 (4.04)	0.93 (0.76)
OOP	12344.68 (56.70)	419.85 (2.82)	208.45 (4.31)	4.34 (0.53)	450.42 (35.61)	0.924 (0.64)
Total	12975.13 (56.70)	577.89 (2.82)	234.95 (4.31)	13.05 (0.53)	527.97 (4.04)	0.95 (0.64)

	Population Aged 70 or Older	Obesity Rate	Smoking Rate	GSI	Face Coverings
BEV	16.24% (9.72%)	30.80% (19.90%)	29.30% (16.00%)	62.35 (41.57)	2.90 (0.46)
BIS	18.49% (11.88%)	25.70% (4.30%)	32.70% (19.50%)	57.83 (34.34)	2.34 (0.87)
NHI	10.79% (4.32%)	29.40% (4.70%)	25.20% (13.90%)	67.47 (49.11)	3.00 (1.53)
OOP	9.73% (3.05%)	36.20% (2.82%)	39.40% (11.50%)	71.75 (58.71)	2.88 (2.39)
Total	18.49% (3.05%)	36.20% (2.82%)	39.40% (11.50%)	71.74 (34.34)	3.00 (0.46)

** Minimums are listed in parenthesis*

Table 3: Regression on Total Deaths per Million

	Total Deaths per Million	P-value
Health System		
BEV	331.1198	0.169
BIS	249.9828	0.311
NHI	71.42168	0.609
Demographic		
Population Density	0.0351202	0.93
Human Development Index	507.8002	0.799
Comorbidities		
Aged 70 or Older	3.009218	0.925
Obesity Rate	659.9593	0.584
Smoking Rate	-313.6524	0.711
Governmental		
Government Stringency Index	5.259343	0.472
Face Coverings	173.009	0.174
Observations*	18	
Adjusted-R^2	0.4011	

*Observations are an average of all data collected between Jan. 1, 2020 and Dec. 8, 2020

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